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(54) Machine having an operating unit movable in a plane

(57) A machine (1)(42)(43) wherein a frame (2) supports at least one operating unit (3)(3a,3b)(3c) via the interposition of an actuating device (4) for enabling the operating unit (3)(3a,3b)(3c) to move in a plane; and wherein the actuating device (4) is defined by two electric motors (14,24) (14,24a,24b) (14c,24c), the respective axes (6,21) (6,21a,21b) of which are perpendicular to the plane of movement of the operating unit (3) (3a, 3b) (3c); and wherein a rotor (15) (25) of one (14) (24) of the two motors (14,24) is supported by the frame (2) and eccentrically supports a stator (23)(13) of the other motor (24) (14), a rotor (25)(15) of which supports the operating unit (3) in an eccentric position.

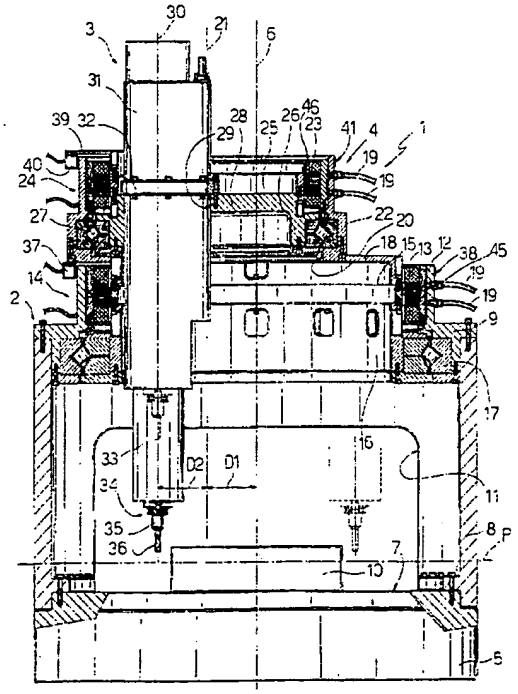

Fig.1

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Description

[0001] The present invention relates to a machine.

[0002] More specifically, the present invention relates to a machine of the type comprising a supporting frame; an operating unit fitted movably to said frame; and an actuating device for moving the operating unit with respect to said frame and with respect to at least two axes defining a travel plane; the operating unit comprising an operating head movable with respect to said frame along at least one further axis.

[0003] The actuating device of known machines of the above type normally comprises a first straight slideway along which runs a first powered slide supporting a second straight slideway, the projection of which on said plane forms an angle of other than zero with the projection of the first slideway on the same plane. The actuating device also comprises a second slide mounted to run along the second slideway and supporting the operating unit.

[0004] Known machines of the above type have the drawback of being fairly bulky. That is, the length of each slideway is determined by the size of the relative slide in the direction of the slideway, plus the travel of the slide and the length of two telescopic guards located on opposite sides of the slide to protect the slideway, so that the size, in said plane, of the slideways and slides as a whole for moving the operating unit in said plane is at least twice the amount of travel permitted.

[0005] Moreover, the structure of the straight slideways is complicated by the presence of mechanical stops or bumpers for arresting the slides and preventing them from running off the slideways in the event of improper operation of the slides, and the strength of which is directly proportional to the traveling speed of the slides.

[0006] Finally, moving the operating unit in said plane using translating slides calls for moving the slides continually back and forth along the relative slideways, thus resulting in severe inertia, which severely impairs the accuracy of the machine unless provision is made for a fairly rigid, heavy frame, which is therefore also fairly bulky and expensive to produce, install and assemble.

[0007] It is an object of the present invention to provide a machine of the above type designed to eliminate the aforementioned drawbacks.

[0008] According to the present invention, there is provided a machine comprising a supporting frame; an operating unit fitted movably to said frame; and an actuating device for moving said operating unit with respect to said frame and parallel to a given plane; characterised in that said actuating device comprises a main electric motor in turn comprising a main stator integral with said frame, and a main rotor fitted to the main stator and rotating about a main axis with respect to the main stator; and at least one secondary electric motor in turn comprising a secondary stator integral with said main rotor, and a secondary rotor fitted to the secondary stator and rotating about a secondary axis movable with said main rotor; said main axis and said secondary axis being perpendicular to said plane, and being separated from each other by a first given distance of other than zero; said operating unit being supported eccentrically by said secondary rotor; and said first distance being less than a radius of the main rotor.

[0009] A number of non-limiting embodiments of the invention will be described by way of example with reference to the accompanying drawings, in which:

Figure 1 shows a schematic front view, with parts removed for clarity, of a machine in accordance with the teachings of the present invention;

Figure 2 shows a top plan view of the Figure 1 machine;

Figure 3 shows a first variation of the Figure 1 machine;

Figure 4 shows a second variation of the Figure 1 machine.

[0010] Number 1 in Figure 1 indicates as a whole a machine comprising a frame 2 supporting an operating unit 3 - of the type described, for example, in the present Applicant's European Patent No. 0563862 - by means of an actuating device 4 for moving operating unit 3, with respect to frame 2, parallel to a reference plane P, which, in the example shown, is horizontal, but which, in other embodiments not shown, may be other than horizontal.

[0011] Frame 2 comprises a cylindrical bed 5, which has a longitudinal main axis 6 perpendicular to plane P and supports, at a top surface 7 parallel to plane P, a tubular body 8, a first end of which is connected integrally to bed 5 along an outer periphery of surface 7, and a second end of which is fitted integrally with an inner flange defined by an annular plate 9 coaxial with main axis 6. Frame 2 supports a work table 10, which is located on surface 7 of bed 5, inside tubular body 8, and is accessible from the outside through two diametrical openings 11 (only one shown) formed in tubular body 8.

[0012] At its inner periphery, annular plate 9 supports a further tubular body 12, which is coaxial with main axis 6, and an inner lateral surface of which is fitted integrally with a main stator 13 of a known main electric torque motor 14 coaxial with main axis 6. In addition to main stator 13, main torque motor 14 also comprises a main rotor 15 having a cylindrical outer lateral surface 45 and defining an intermediate portion of a further tubular body 16 coaxial with main axis 6. Tubular body 16 is supported, at one end housed inside tubular body 8, by tubular body 8 itself via the interposition of a crossed-tapered-roller bearing 17 coaxial with main axis 6, and is closed at the other end by a flat circular plate 18 parallel to plane P. Tubular body 12 supports a known hydraulic device 19 for cooling main stator 13.

[0013] Plate 18 has an eccentric through hole 20 coaxial with a secondary axis 21, which is parallel to main axis 6 and separated from main axis 6 by a first given

distance D1 which is less than a radius of main rotor 15.

[0014] At hole 20, plate 18 supports a further tubular body 22 coaxial with axis 21, and an inner lateral surface of which is fitted integrally with a secondary stator 23 of a known secondary electric torque motor 24 coaxial with secondary axis 21 and comprising a secondary rotor 25, which has a cylindrical outer lateral surface 46 and defines an end portion of a further tubular body 26 coaxial with axis 21. The projection on plane P of the outer lateral surface 46 of secondary rotor 25 is within the projection on plane P of the outer lateral surface 45 of main rotor 15.

[0015] The end of tubular body 26 housed inside tubular body 22 is supported by tubular body 22 itself via the interposition of a crossed-tapered-roller bearing 27 coaxial with secondary axis 21.

[0016] Tubular body 26 is fitted with a flat intermediate plate 28 parallel to plane P and having an eccentric through opening 29, which is coaxial with an axis 30 parallel to main axis 6 and separated by a second given distance D2 from secondary axis 21. Operating unit 3 is fitted through opening 29, is of known type, and comprises a substantially parallelepiped-shaped casing 31 supported by plate 28 and connected to plate 28 at an outer intermediate flange 32; a powered cylindrical sleeve 33 coaxial with and movable along axis 30; and a toolhead 34, which, in the example shown, is fixed with respect to sleeve 33 and comprises a spindle 35 for rotating a tool 36, coaxial with axis 30, about axis 30, but which, in variations not shown, is mounted to move, with respect to sleeve 33, about two or more separate axes.

[0017] Tubular body 22 is fitted integrally with a feedback sensor 37, which is movable with main rotor 15 along a graduated scale 38 drawn on the outer surface of tubular body 12 to emit a signal indicating the angular position of main rotor 15 about main axis 6 and with respect to frame 2; and rotor 25 is fitted integrally, by means of a bracket 39, with a feedback sensor 40, which is movable with rotor 25 along a graduated scale 41 drawn on the outer surface of tubular body 22 to emit a signal indicating the angular position of rotor 25 about secondary axis 21 and with respect to tubular body 22.

[0018] In actual use, actuating device 4 moves operating unit 3 in plane P by combining rotation of the two rotors 15 and 25 about axes 6 and 21. Main rotor 15 rotates both operating unit 3 and secondary rotor 25 about main axis 6, and secondary rotor 25 in turn rotates operating unit 3 about secondary axis 21.

[0019] Axis 30 of operating unit 3 can be positioned by actuating device 4 at any point on an annular surface having, in absolute value, an outside radius of D2+D1, and an inside radius of D1-D2. When, as in the example embodiment described, second distance D2 equals first distance D1, said annular surface is a flat, substantially circular surface.

[0020] Machine 1 as described has the advantage of being smaller than known machines, on account of its overall cylindrical structure being much more compact than those of linear-axis machines. Moreover, any forces transmitted by operating unit 3 to motors 14 and 24 are discharged on frame 2 in the form of distributed tensile and compression stress which frame 2, being substantially cylindrical, can easily absorb without too much trouble. As a result, for a given rigidity, frame 2 may be much lighter than those of corresponding linear machines.

[0021] Machine 1 also has the further advantage of not requiring mechanical stops, by the movements of operating unit 3 being achieved by a combination of circular movements.

[0022] The Figure 3 embodiment relates to a machine 42 similar to machine 1, and the component parts of which are indicated, wherever possible, using the same reference numbers as for corresponding parts of machine 1.

[0023] Machine 42 provides for simultaneously working two identical parts and/or for simplifying any toolchange operation with no downtime involved. For which purpose, machine 42 differs from machine 1 by plate 18 having two eccentric through holes 20a, 20b. Hole 20a is coaxial with a secondary axis 21a parallel to main axis 6 and separated from main axis 6 by a given distance D1; and hole 20b is coaxial with a secondary axis 21b parallel to main axis 6 and separated from main axis 6 by a given distance D1. More specifically, holes 20a, 20b are diametrically opposite and symmetrical with respect to main axis 6.

[0024] At hole 20a, plate 18 supports a secondary electric torque motor 24a, which comprises a secondary stator 23a and a secondary rotor 25a, both coaxial with secondary axis 21a. Secondary rotor 25a has a cylindrical outer lateral surface 46a, and is fitted integrally with an eccentric operating unit 3a coaxial with an axis 30a parallel to and separated by a distance D2 from secondary axis 21a.

[0025] Operating unit 3a is similar to operating unit 3 of machine 1, and comprises a substantially parallelepiped-shaped casing 31a supported by plate 28a and connected to plate 28a at an outer intermediate flange 32a; a powered cylindrical sleeve 33a coaxial with and movable along axis 30a; and a toolhead 34a, which, in the example shown, is fixed with respect to sleeve 33a and comprises a spindle 35a for rotating a tool 36a, coaxial with axis 30a, about axis 30a, but which, in variations not shown, is mounted to move, with respect to sleeve 33a, about two or more separate axes.

[0026] At hole 20b, plate 18 supports a secondary torque motor 24b, which comprises a secondary stator 23b and a secondary rotor 25b, both coaxial with secondary axis 21b. Secondary rotor 25b has a cylindrical outer lateral surface 46b, and is fitted integrally with an eccentric operating unit 3b coaxial with an axis 30b parallel to and separated by a distance D2 from secondary axis 21b.

[0027] Operating unit 3b is similar to operating unit 3 of machine 1, and comprises a substantially parallele-

piped-shaped casing 31b supported by plate 28b and connected to plate 28b at an outer intermediate flange 32b; a powered cylindrical sleeve 33b coaxial with and movable along axis 30b; and a toolhead 34b, which, in the example shown, is fixed with respect to sleeve 33b and comprises a spindle 35b for rotating a tool 36b, coaxial with axis 30b, about axis 30b, but which, in variations not shown, is mounted to move, with respect to sleeve 33b, about two or more separate axes. The projection on plane P of each of outer lateral surfaces 46a and 46b is within the projection on plane P of outer lateral surface 45 of main rotor 15.

[0028] The Figure 4 embodiment relates to a machine 43 similar to machine 1, and the component parts of which are indicated, wherever possible, using the same reference numbers as for corresponding parts of machine 1.

[0029] Machine 43 differs from machine 1 by the free end of tubular body 8 supporting a cup-shaped body 44 fitted onto tubular body 8 and comprising an annular end wall defined by an annular plate 9c, which is coaxial with main axis 6 and is fitted integrally with a main electric torque motor 14c. Main torque motor 14c comprises a main stator 13c coaxial with main axis 6 and integral with annular plate 9c, and a main rotor 15c also coaxial with main axis 6 and having a cylindrical outer lateral surface 45c. Main rotor 15c is integral with a tubular body 22c coaxial with main axis 6 and connected in rotary manner to cup-shaped body 44 via the interposition of a crossed-tapered-roller bearing 27c coaxial with main axis 6.

[0030] Tubular body 22c supports a known hydraulic device 19c for cooling main rotor 15c, and is fitted integrally at the bottom end with an annular plate 18c parallel to plane P and having an eccentric through hole 20c coaxial with main axis 6 and fitted through with tubular body 8.

[0031] The outer periphery of plate 18c is fitted integrally with a secondary electric torque motor 24c comprising a secondary stator 23c defining an intermediate portion of a further tubular body 16c coaxial with a secondary axis 21 parallel to and separated by a first given distance D1 from main axis 6. Secondary torque motor 24c comprises a secondary rotor 25c coaxial with secondary axis 21 and having a cylindrical outer lateral surface 46c. Secondary rotor 25c is integral with a tubular body 12c connected in rotary manner to tubular body 16c via the interposition of a crossed-tapered-roller bearing 17c coaxial with secondary axis 21; and tubular body 12c supports known hydraulic device 19c for cooling secondary rotor 25c.

[0032] The outer periphery of tubular body 12c is fitted with operating unit 3c, which is similar to operating unit 3 of machine 1 and comprises a substantially parallelepiped-shaped casing 31c connected to tubular body 12c at an outer intermediate longitudinal fastening plate 32c. Operating unit 3c also comprises a powered cylindrical sleeve 33c coaxial with and movable along an axis 30c parallel to main axis 6 and separated by a given distance D2 from secondary axis 21; and a toolhead 34c which, in the example shown, is fixed with respect to sleeve 33c and comprises a spindle 35c for rotating a tool 36c, coaxial with axis 30c, about axis 30c. In variations not shown, toolhead 34c is mounted to move, with respect to sleeve 33c, about two or more separate axes.

[0033] Tubular body 22c is fitted integrally with a feedback sensor 37c, which is movable with main rotor 15c along a graduated scale 38c drawn on the outer surface of tubular body 12c to emit a signal indicating the angular position of secondary rotor 25c about secondary axis 21 and with respect to frame 2; and main stator 13c is fitted integrally, by means of a bracket 39c, with a feedback sensor 40c, which faces a graduated scale 41c drawn on the outer surface of body 22c and movable with main rotor 15c to emit a signal indicating the angular position of main rotor 15c about main axis 6 and with respect to tubular body 22c.

[0034] The projection of outer lateral surface 45c of main rotor 15c on plane P is within the projection of outer lateral surface 46c of secondary rotor 25c on plane P.

Claims

1. A machine (1) (42) (43) comprising a supporting frame (2); an operating unit (3) (3a,3b) (3c) fitted movably to said frame (2); and an actuating device (4) for moving said operating unit (3) (3a,3b) (3c) with respect to said frame (2) and parallel to a given plane; characterised in that said actuating device (4) comprises a main electric motor (14) (14c) in turn comprising a main stator (13)(13c) integral with said frame (2), and a main rotor (15) (15c) fitted to the main stator (13) (13c) and rotating about a main axis (6) with respect to the main stator (13) (13c); and at least one secondary electric motor (24) (24a, 24b) (24c) in turn comprising a secondary stator (23) (23a,23b) (23c) integral with said main rotor (15) (15c) , and a secondary rotor (25) (25a,25b) (25c) fitted to the secondary stator (23)(23a,23b) (23c) and rotating about a secondary axis (21)(21a, 21b) movable with said main rotor (15) (15c); said main axis (6) and said secondary axis (21) (21a, 21b) being perpendicular to said plane, and being separated from each other by a first given distance of other than zero; said operating unit (3) (3a,3b) (3c) being supported eccentrically by said secondary rotor (25)(25a,25b)(25c); and said first distance being less than a radius of the main rotor (15) (15c).

2. A machine (1) (42) (43) as claimed in Claim 1, wherein said operating unit (3) (3a,3b) (3c) has a longitudinal axis (30) (30a,30b) (30c) parallel to said main axis (6) and said secondary axis (21)(21a, 21b).

3. A machine (1) (42) as claimed in Claim 1 or 2,

wherein said operating unit (3) (3a,3b) has a longitudinal axis (30) (30a,30b) separated from said secondary axis (21) (21a,21b) by a second distance of other than zero and less than a radius of the secondary rotor (25) (25a,25b).

4. A machine (1) (42) as claimed in Claim 3, wherein said second distance equals said first distance.

5. A machine (1) (42) as claimed in Claim 3 or 4, wherein said operating unit (3) (3a,3b) extends through at least said main rotor (15) (15c) or said secondary rotor (25) (25a,25b) .

6. A machine (43) as claimed in Claim 1 or 2, wherein said operating unit (3c) has a longitudinal axis (30c) separated from said secondary axis (21) by a second distance greater than a radius of the secondary rotor (25c).

7. A machine (42) as claimed in Claim 1 or 2, wherein said main rotor (15) supports two said secondary motors (24a) (24b), each having a respective secondary axis (21a) (21b) perpendicular to said plane and eccentric with respect to said main axis (6); each said secondary motor (24a)(24b) comprising a relative said secondary stator (23a)(23b) integral with said main rotor (15), and a relative said secondary rotor (25a)(25b) fitted in rotary manner to the relative said secondary stator (23a)(23b); and each said secondary rotor (25a) (25b) supporting eccentrically a respective said operating unit (3a) (3b).

8. A machine (42) as claimed in Claim 7, wherein said two secondary axes (21a) (21b) are symmetrical with respect to said main axis (6).

9. A machine (42) as claimed in Claim 7 or 8, wherein each said operating unit (3a) (3b) extends through the relative said secondary rotor (25a) (25b).

10. A machine (1) (42) (43) as claimed in one of the foregoing Claims, wherein said main electric motor (14) (14c) and said secondary motor (24) (24a,24b) (24c) are electric torque motors.

11. A machine (1) (42) (43) as claimed in any one of the foregoing Claims, wherein said frame (2) is a substantially cylindrical frame.

12. A machine (1) (42) (43) as claimed in any one of the foregoing Claims, wherein said main rotor (15) (15c) and said secondary rotor (25) (25a,25b) (25c) have respective cylindrical outer lateral surfaces (45) (45c) (46) (46a,46b) (46c); and wherein the projection on said plane of said outer lateral surface (46) (46a,46b) (45c) of one of said main rotor (15) (15c) and said secondary rotor (25) (25a,25b) (25c) is always, in use, within the projection on the same plane of said outer lateral surface (45) (46c) of the other of said main rotor (15) (15c) and said secondary rotor (25) (25a,25b) (25c).

13. A machine (1) (42) (43) as claimed in any one of the foregoing Claims, wherein said operating unit comprises an operating head (34)(34a,34b)(34c) movable with respect to said frame (2) along at least one further longitudinal axis (30) parallel to said main axis (6) and said secondary axis (21)(21a,21b).

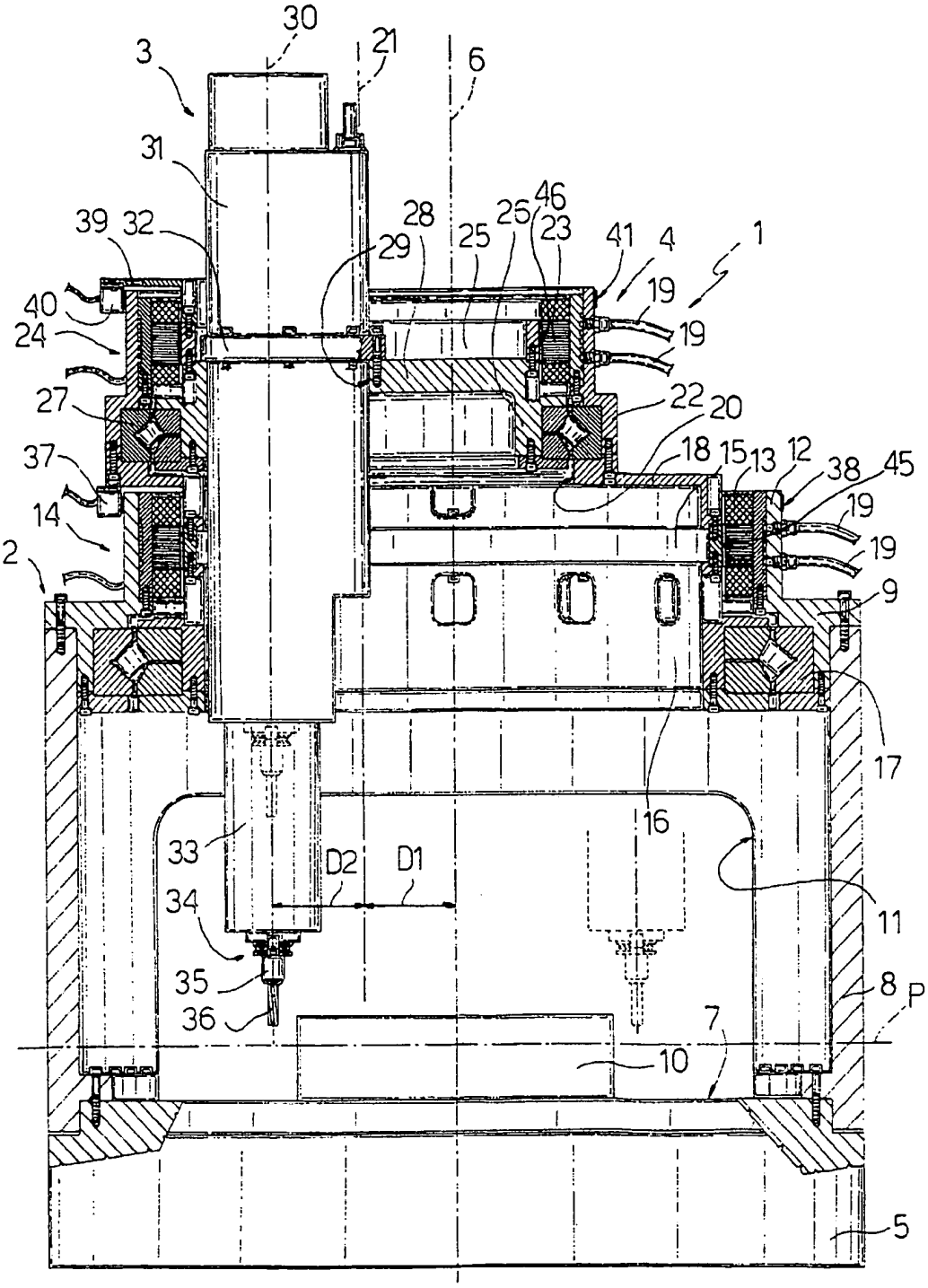
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Fig.1

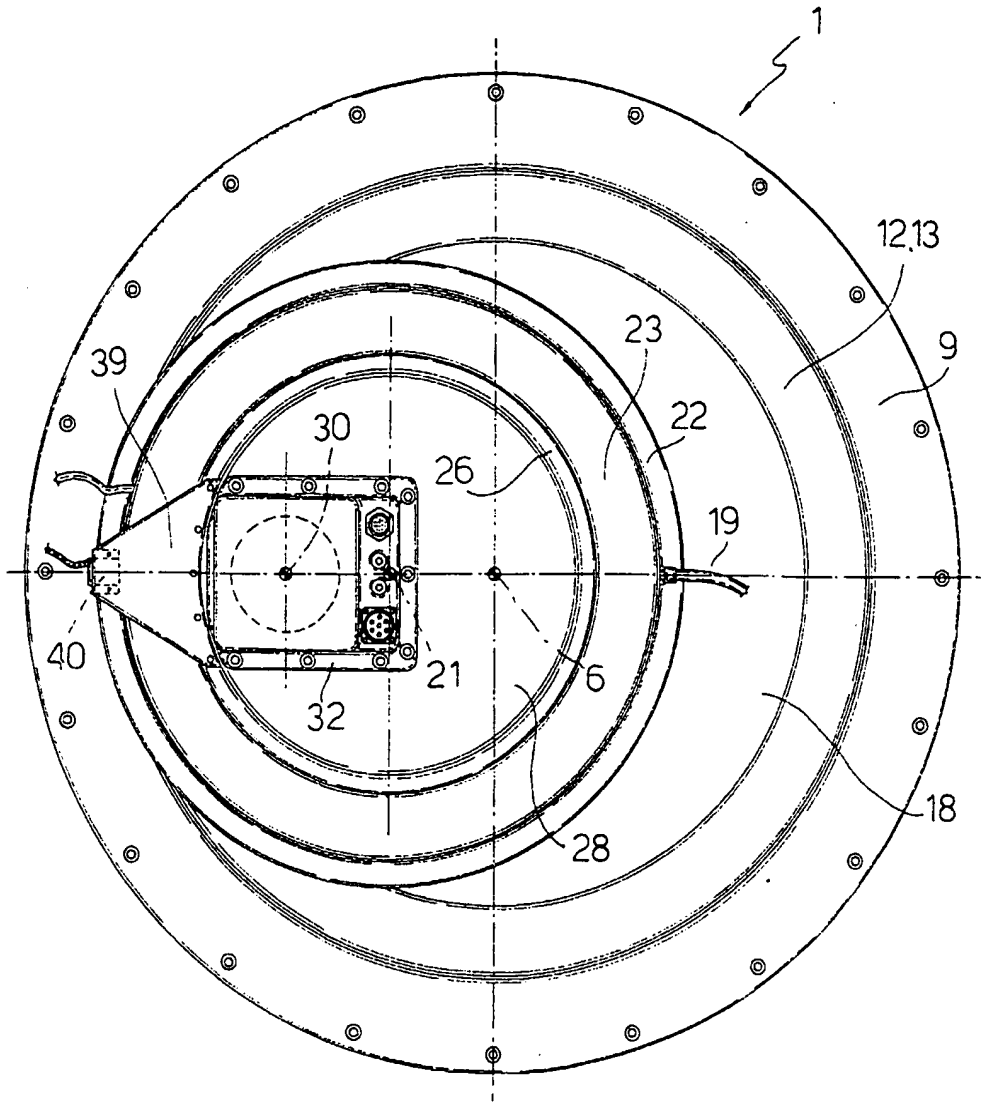

Fig.2

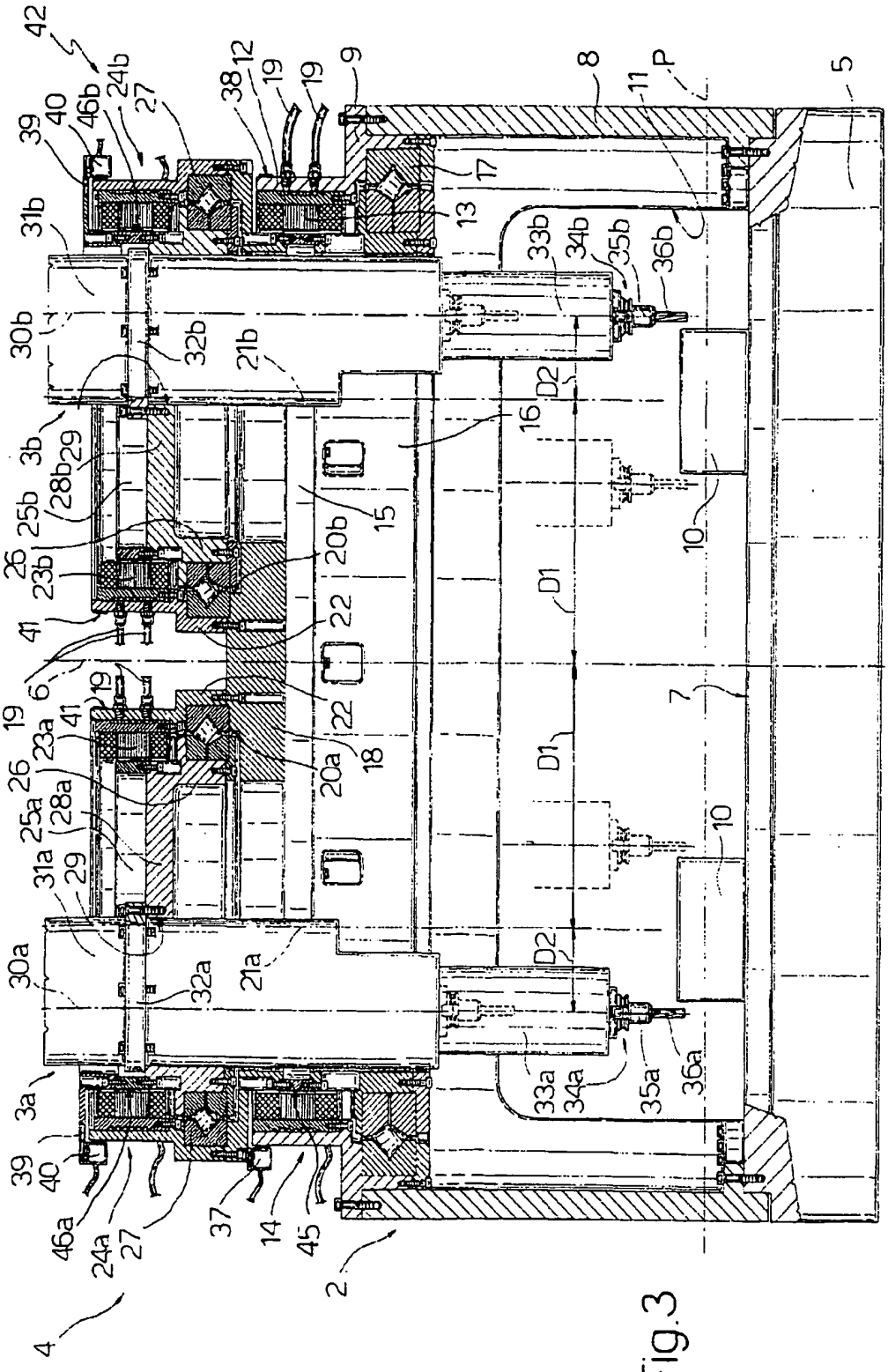
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Fig.3

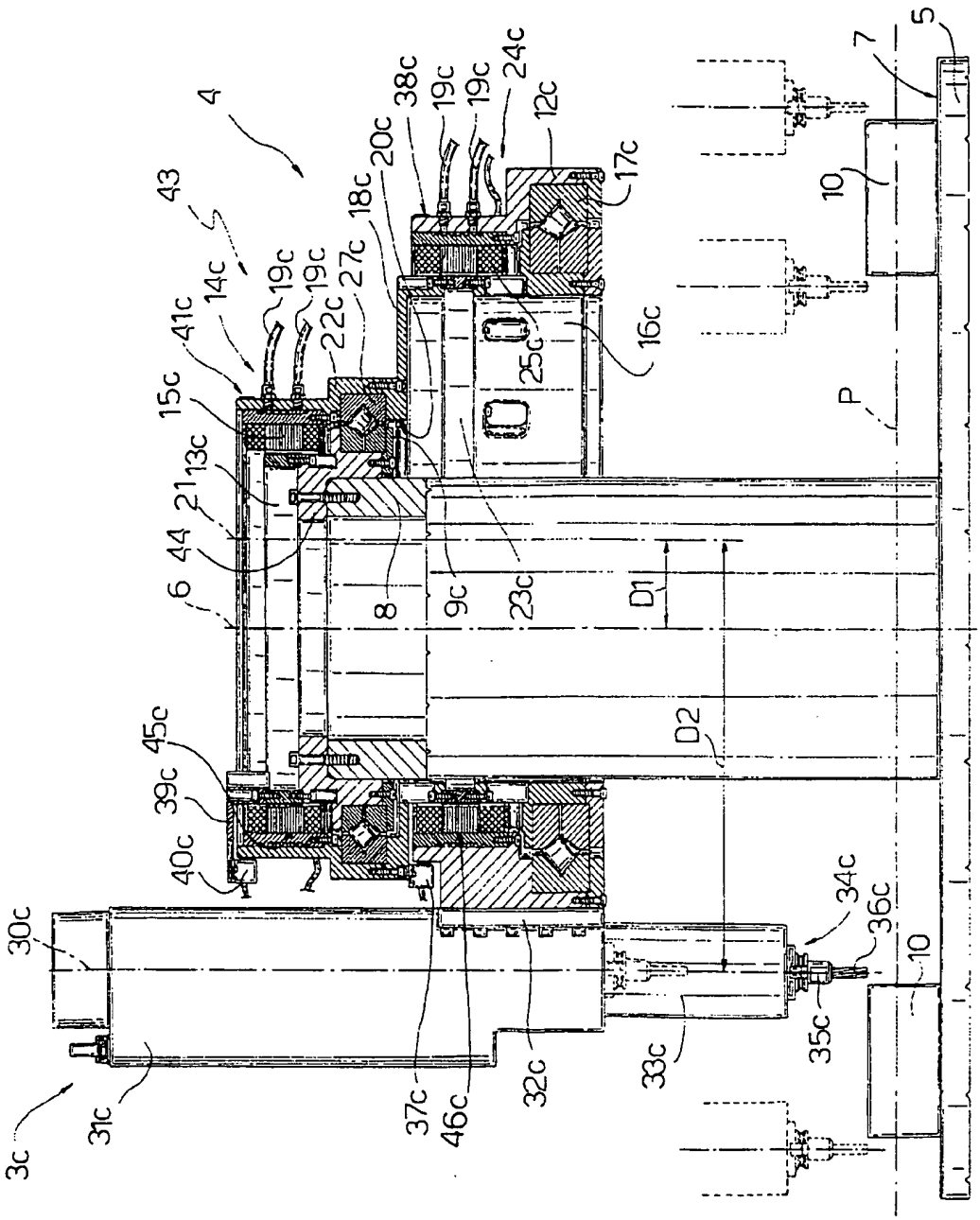
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Fig.4